

In re application of: THE REGENTS OF THE UNIVERSITY OF CALIFORNIA  
 International Application No.: PCT/US03/39211  
 International Filing Date: 9 December 2003  
 Agent's Reference: 30794108WO01  
 Title: HIGHLY EFFICIENT GALLIUM NITRIDE BASED LIGHT EMITTING  
 DIODES VIA SURFACE ROUGHENING

---

AP3 Rec'd PCT/PTO 07 JUN 2005

AMENDMENT UNDER ARTICLE 19  
BEFORE THE INTERNATIONAL BUREAU OF WIPO

**VIA FACSIMILE  
 CONFIRMATION VIA FEDERAL EXPRESS**

The International Bureau of WIPO  
 34, chemin des Colombettes  
 1211 Geneva 20  
 SWITZERLAND

Dear Sir or Madam:

In response to the Search Report dated 26 May 2004, please amend the above-identified application as indicated below:

IN THE CLAIMS

It is requested that the claims of the above-referenced application be amended as provided on replacement pages 16-18 attached herewith. No new matter has been introduced by these amendments. The claims correspond to the current PCT claims as follows:

<u>Claims</u>	<u>Status</u>
1-2	Amended
3-7	Unchanged
8	Amended
9-14	Unchanged
15-16	Amended
17-18	Unchanged

REMARKS

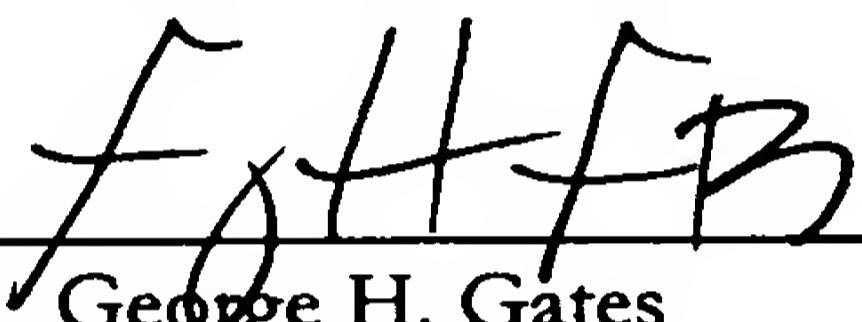
In view of the above amendments, it is submitted that the claims are in a condition for a positive examination report. If this is not the case, the Examiner is encouraged to contact the Applicant's representative since a positive report is requested.

Please direct any inquiry to the below-signed attorney.

Respectfully submitted,

GATES & COOPER LLP  
6701 Center Drive West, Suite 1050  
Los Angeles, California 90045  
United States of America  
(310) 641-8797

ATTORNEYS FOR APPLICANT(S)

Date: 22 July 2004  
By:   
George H. Gates

WHAT IS CLAIMED IS:

1. A gallium nitride (GaN) based light emitting diode (LED), wherein light is extracted through a nitrogen face (N-face) of the LED and a surface of the N-face is roughened.

5

2. The GaN LED of claim 1, wherein the surface of the N-face is roughened into one or more cones.

10 3. The GaN LED of claim 1, wherein the roughened surface reduces light reflections occurring repeatedly inside the LED, and thus extracts more light out of the LED.

15 4. The GaN LED of claim 1, wherein the surface of the N-face is roughened by an anisotropic etching.

5. The GaN LED of claim 4, wherein the anisotropic etching is a dry etching.

20 6. The GaN LED of claim 4, wherein the anisotropic etching is a photo-enhanced chemical (PEC) etching.

7. The GaN LED of claim 1, wherein the N-face is an n-type layer of the GaN LED.

25 8. The GaN LED of claim 1, wherein the N-face is prepared by a laser lift off (LLO) technique.

9. The GaN LED of claim 1, wherein the LED is grown on a c-plane GaN wafer and a gallium face (Ga-face) is a p-type layer.

10. The GaN LED of claim 1, wherein the LED is comprised of an n-type electrode, n-type layer, active region, p-type layer and p-type electrode.

5 11. The GaN LED of claim 10, wherein the n-type layer, active region and p-type layer are each comprised of a (B, Al, Ga, In)N alloy.

10 12. The GaN LED of claim 10, wherein the p-type electrode has a property of high reflection to decrease light absorption and to increase light reflection toward the surface of the n-type layer.

15 13. The GaN LED of claim 10, wherein the LED includes a current-blocking layer aligned under the n-type electrode to keep the current from concentrating below the n-type electrode, so that absorption of light emission under the n-type electrode can be avoided and extraction efficiency can be increased.

14. The GaN LED of claim 10, wherein the LED includes a current-confining frame made of an insulator to restrain leakage current through the sidewalls of the LED without significantly decreasing an emitting area.

20

15. The GaN LED of claim 2, wherein the roughened surface is comprised of a plurality of hexagonal shaped cones that have an angle equal to or smaller than:

$$2 \sin^{-1}(n_{air} / n_s) \approx 47.2^\circ$$

25

for GaN, where  $n_{air}$  is a refractive index of air and  $n_s$  is a refractive index of GaN.

16. The GaN LED of claim 2, wherein the roughened surface is comprised of a plurality of hexagonal shaped cones that have an angle equal to or smaller than:

$$2 \sin^{-1}(n_{enc} / n_s)$$

5 for epoxy, where  $n_{enc}$  is a refractive index of epoxy and  $n_s$  is a refractive index of GaN.

17. A method of creating a gallium nitride (GaN) based light emitting diode (LED), wherein light is extracted through a nitrogen face (N-face) of the LED, 10 comprising:

roughening a surface of the N-face into one or more cones.

18. A light emitting diode (LED) comprised of an n-type electrode, n-type layer, active region, p-type layer and p-type electrode, wherein a surface of the n-type 15 layer is roughened by an anisotropic etching into one or more cones and light is extracted through the roughened surface of the n-type layer.

Howard Hughes Center  
6701 Center Drive West, Suite 1050  
Los Angeles, CA 90045  
(310) 641-8797 (TEL)  
(310) 641-8798 (FAX)

*Gates & Cooper LLP*

# Fax

---

To: International Bureau of WIPO

From: George H. Gates

---

Fax: 011 41-22 740 14 35

Pages: 6

---

Phone: 011 41-22 338 83 38

Date: July 22, 2004

---

Re: PCT/US03/39211

G&C: 30794108WO01

---

This transmission contains information that is confidential and/or legally privileged. It is intended for use only by the person to whom it is directed. If you have received this facsimile in error, please notify us by phone immediately so that we can arrange for the return of the original documents to us.

If you do NOT receive all of the pages, please phone or fax us at the above numbers.

● Documents Transmitted:

- (1) Letter re Amendment Under Article 19 (2pp); and
- (2) Replacement Claim pages 16-18.